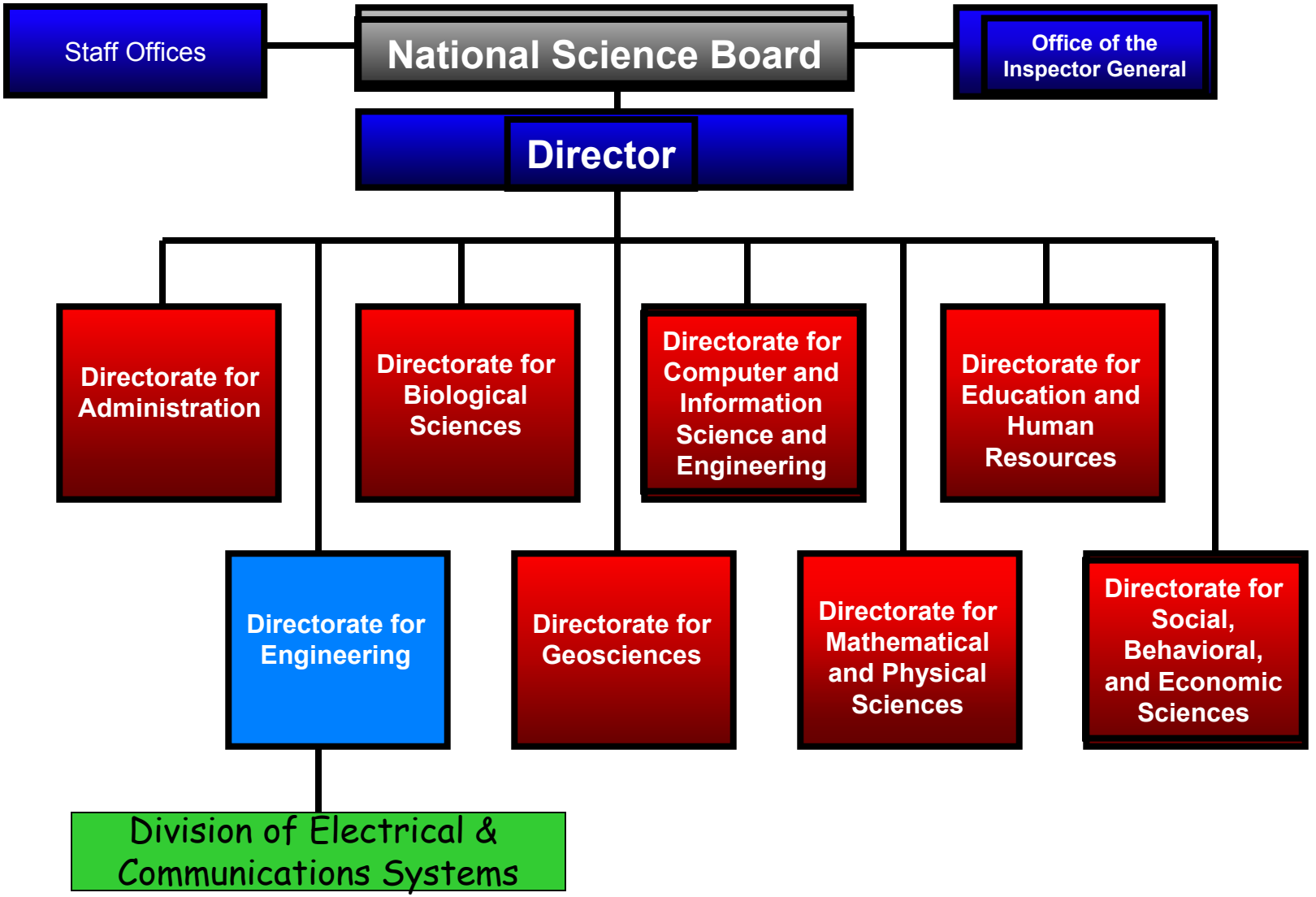
SSI Program Planning Meeting, November 13-14, 2003
Doubletree Hotel, Crystal City, VA

NSF Programs in Organic Electronics and Photonics Basic Research at Academia

"Enabling the Nation's Future through Discovery, Learning and Innovation"
Vision of NSF

Vasundara V. Varadan
Division Director – Electrical & Communications Systems Division

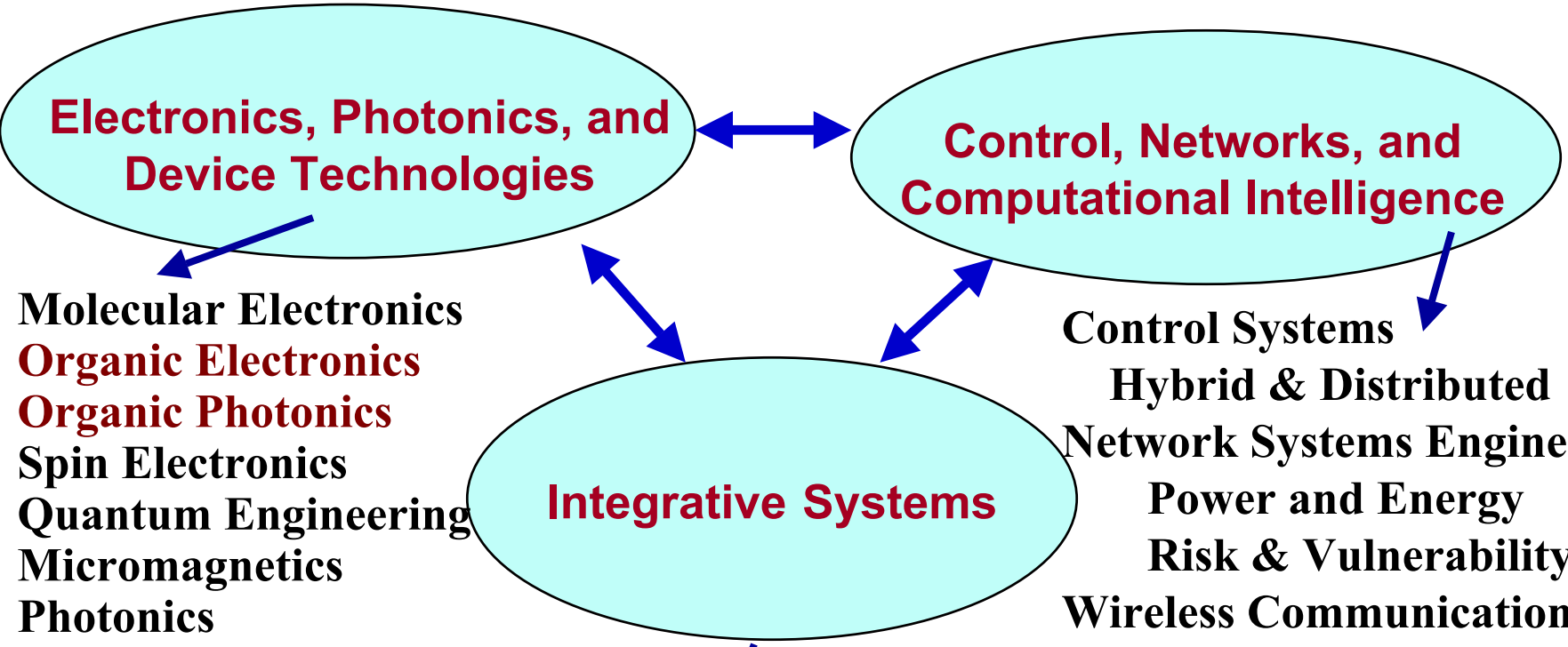
National Science Foundation



Mission:

The mission of the ECS Division is to address fundamental research issues underlying component and device technologies, networking, control and systems principles at the nano, micro and macro scales; to support the integration and networking of intelligent systems for a variety of applications; and to ensure the education of a diverse workforce to support the continued development of these technologies as drivers for the global economy.

Division of Electrical and Communications Systems



Molecular Electronics
Organic Electronics
Organic Photonics
Spin Electronics
Quantum Engineering
Micromagnetics
Photonics
Optoelectronics
Biomolecular Devices
MEMS/NEMS
Sensors and Actuators
Wireless Technologies
Electromagnetics

System on a Chip
Macrosystems
Smart Structures

Control Systems
Hybrid & Distributed
Network Systems Engineering
Power and Energy
Risk & Vulnerability
Wireless Communications
Optical Networks
Imaging Systems
Modeling and Simulation
Quantum Information Systems

http://www.eng.nsf.gov/ecs/

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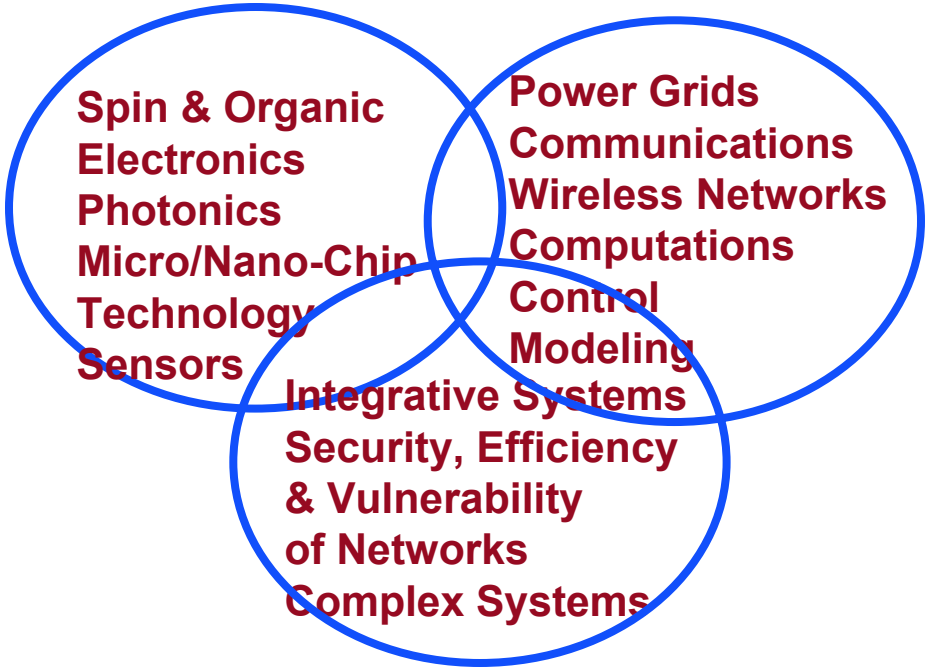
ECS AT THE CROSSROADS



ECS has joint programs not only with all divisions within the Engineering Directorate but also with CISE, MPS, SBE, BIO and E□HR as well as other agencies such as DARPA, ONR, NASA, EPRI, NIH, DOE, NIST and trade groups such as EPRI, OIDA, SRC

SSL Pertinent Programs

Optoelectronics, Photonics
EPDT Program
Dr. Fil Bartoli, Program Director

Photovoltaics, Organic Electronics, Power Electronics
EPDT Program
Dr. Usha Varshney, Program Director

Modes of Funding for Organic Electronics And Photonics Programs

- Core funds

- Nanoscale Science & Engineering
  NSF Priority Area
    - Nanotechnology Interdisciplinary Research Teams (NIRT)
    - Nanoscale Exploratory Research (NER)
    - Nanosclae Science & Engineering Centers (NSEC)
    - Nanoscale Science & Engineering Education (NSEE)

- ECS Special Initiatives

Photonics Technology Access Program (PTAP)

- Follow-on to the concluded U.S.-Japan Joint Optoelectronics Project
- Domestic-oriented program using Broker concept to provide U.S. researchers access to prototype photonics devices and components
- $4M, 3 year grant awarded to the Optoelectronics Industry Development Association (OIDA)
- Jointly funded by NSF $1,800,000 and DARPA $2,191,863

Program Director: Dr. Lawrence Goldberg, ECS

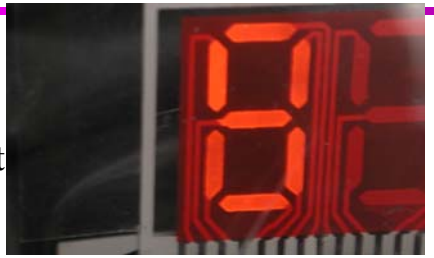
Multilayered Polymer Hybrid Optoelectronic Devices

Sue A. Carter, University of California, Santa Cruz

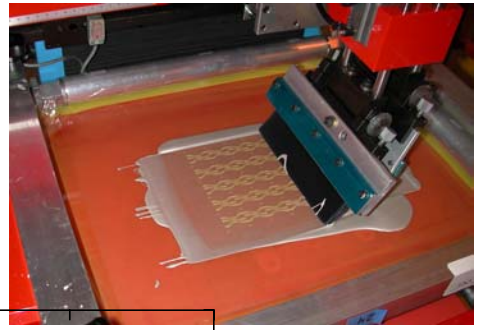
ECS-0101794

• Fully Printed polymer-based light emitting displays manufactured under atmospheric conditions with lifetimes > 100 hours at 300 cds/m^2 and quantum efficiencies > 2% enabling greatly reduced costs and greater performance for intermittent flexible display technologies.

Flexible polymer LED on plastic

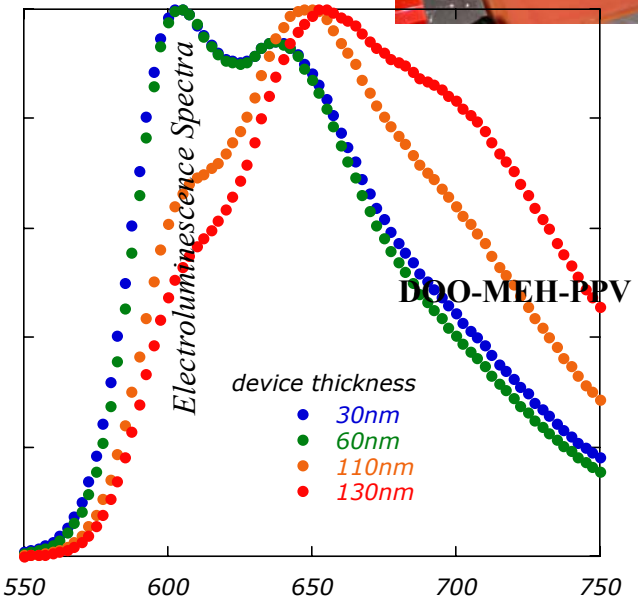


Fully printed 7-segment display



Printing of the top electrode on a polymer hybrid display

• Accurate simulation of optical interference effects on the electroluminescence spectrum of multilayered polymer LEDs as a function of device thickness and position of the excition recombination zone
Enabling the ability to predict color (CIE coordiates) and efficiency of polymer light emitting diodes used in the display and optoelectronics industry.



Multilayered Polymer Hybrid Optoelectronic Devices

Sue A. Carter, University of California, Santa Cruz

ECS-0101794

• Current NSF funding was used to support physics graduate students Eric Jones (5th from left) and Janelle Leger (far right) and electrical engineering undergraduate Mike Hendrick (2nd from left). Previously, funding was used to support Yuko Nakazawa (far left) who is now fully supported on a dissertation diversity fellowship that she was awarded in the Fall of 2002.

• This support involved outreach to under represented groups (Eric -- Latino, Janelle - woman).

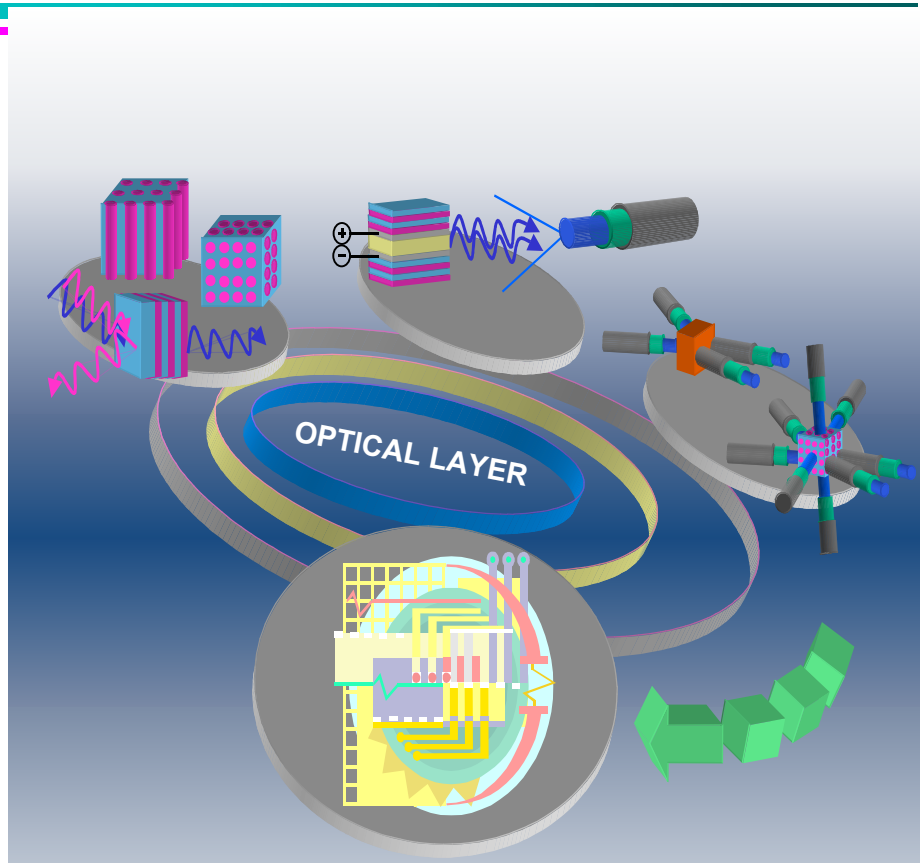
• Eric, Janelle and Yuko all did one or two quarter internships (Fall 2002 through Winter 2003) in industry as part of their educational training.

ON-CHIP MOLECULAR SCALE PATTERNING AND ASSEMBLIES

C. K. Ober, N. P Balsara, G. W. Coates, E. L. Thomas, U. B. Wiesner, Cornell University, UC Berkeley, MIT, ECS-0103297-NIRT

Photonic crystals are a new class of periodic dielectric media that can provide novel ways to control light and serve as the basis for next generation optical communications [above]. We have succeeded in using heat to switch the photonic bandgap (PBG) behavior of nm-scale multilayer stacks suited for visible wavelength optical signal control. This work points the way towards the use of self-assembled block polymeric materials in optical switches, couplers, and isolators.

[Chinedum Osuji, Chi-Yang Chao, Ion Bita, Christopher K. Ober, Edwin L. Thomas, "Temperature Dependent Photonic Band Gap in a Self-Assembled Hydrogen Bonded Liquid Crystalline Diblock Copolymer", *Adv. Mater.*, submitted.]



Related Papers:

Y. Fink, J. N. Winn, S. Fan, C. Chen, J. Michel, J. D. Joannopoulos, E. L.Thomas, *Science* 1998, **282**, 1679.

Osuji, C. O.; Chen, J. T.; Mao, G.; Ober, C. K.; Thomas, E. L. "Understanding and Controlling the Morphology of Styrene-Isoprene Side-Group Liquid Crystalline Diblock Copolymers", *Polymer* (2000), **41(25),** 8897-8907.

The seminal paper by Thomas and coworkers on the use of block copolymers as photonic bandgap materials has provided the basis for many of the concepts explored in the NIRT. At the same time, the collaboration between groups has permitted the incorporation of new molecular designs to produce these thermochromic liquid crystal PBG materials.

ON-CHIP MOLECULAR SCALE PATTERNING AND ASSEMBLIES

C. K. Ober, N. P. Balsara, G. W. Coates, E. L. Thomas, U. B. Wiesner, Cornell University, UC Berkeley, MIT, ECS-0103297-NIRT

Educational/Outreach Activity:

Top:

Prof. C. K. Ober talks to local Ithaca High School students about polymers and their role in advanced technologies including optical communications and microelectronics. As a rural university, Cornell acts as a regional center for outreach to K-12 schools. This day of interaction with high school students involved post-docs and graduate students. This outreach activity was in collaboration with the **Cornell MRSEC**.

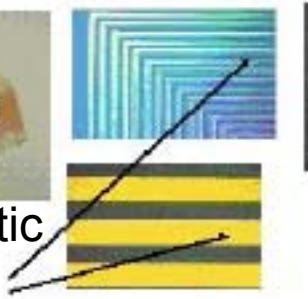
Bottom:

Information exchange in the field of nanotechnology is a vital part of research and outreach. As part of the NIRT activities we hold an annual **Ski Hut Seminar** each January to bring together **graduate students, undergraduates and members of industry** for a 2 day seminar in Ithaca, NY on nanotechnology and microphotonics. The exchange fostered to these meetings has produced several new research leads as a result of stronger collaborations and enhances the involvement of undergrads who participate in research during the academic year.

Low cost, inkjet printed power harvesting circuits on plastics – Vivek Subramanian, UC-Berkeley; ECS 0223931

In this program, the PI and his students have developed a technique to print electronic circuits including inductors, capacitors, diodes, and transistors on plastics using inkjet printing. This will allow the addition of electronics onto an existing package without any significant increase in cost. In 2002, the PI was nominated to Technology Review's list of top 100 young innovators (the TR100)

Closeup of Inductor on plastic

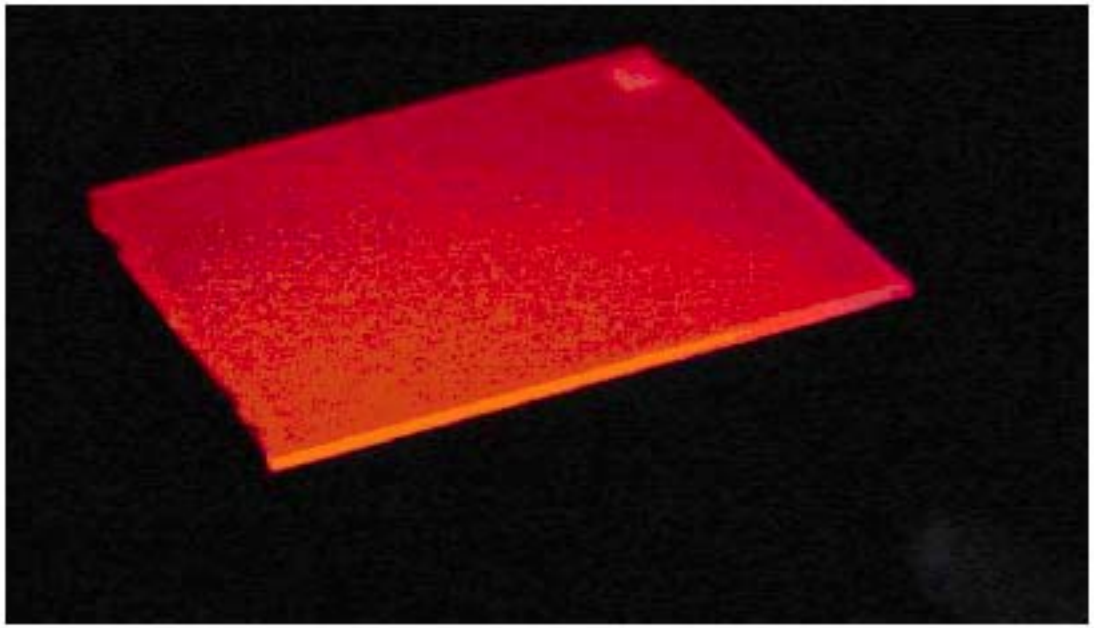


Closeup of capacitor showing layers of gold separated by 100 nm of polyimide

Multiple-Dye Fluorescent Microspheres and Films-A New Approach for Luminescent Solar Concentrators; Bruce Wittmershaus, Pennsylvania State Univ; ECS 9906282

Their research illustrated how using a combination of three dyes improved performance 50% over a luminescent solar concentrator made with just one of the dyes. The concentrators are made from clear polymer sheets containing fluorescent dyes. The dyes absorb sunlight and 75% of their fluorescence is trapped in the plate and concentrated at the edges. There, small strips of semiconductor solar cells absorb the fluorescence converting it to electricity.

Concentration of solar power at upper left corner using total internal reflection.



New Program Preparation

NSF Workshop
Technological Challenges for Flexible, Light-weight, Low-cost and Scalable Organic Electronics and Photonics

January 16-17, 2003, Arlington, VA
Chair: Ananth Dodabalapur, University of Texas - Austin
Co-Chair: Christots Dimitrakopoulos, IBM

Final Report: Available

FY'04 Programs in Planning

Initiative on Technological Challenges Organic Electronics and Photonics - *subject to availability of funds*

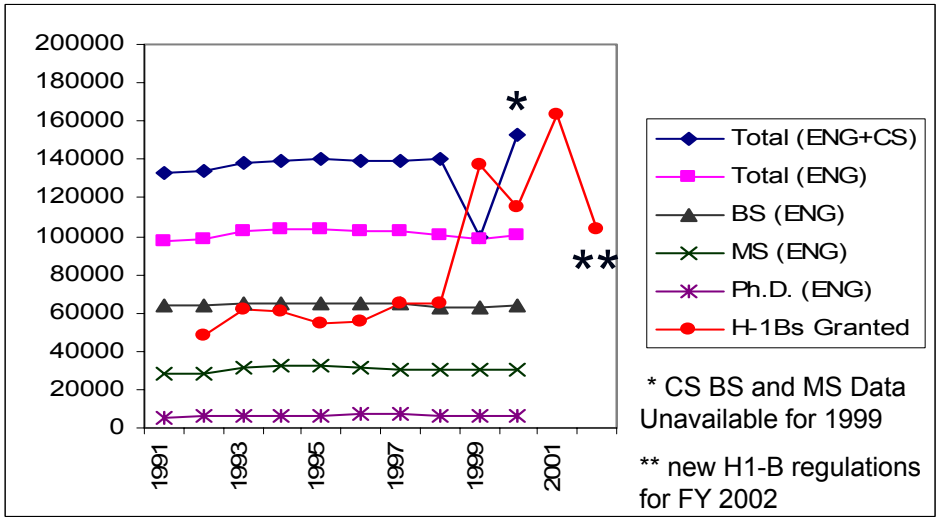
Research issues relating to:

- Quantum optics with organic materials
- Singlet exciton (SE)-to-triplet exciton (TE) ratio in long conjugation-length polymers
- Organic and polymeric light emitting diodes
- (OLEDs). Carrier transport, charge collection, solar spectrum match for organic photovoltaic cells (OPVs)
- Photodegradation and device lifetimes
- Reliability and feasibility of electrically pumped and micro-ring organic lasers
- Conversion efficiencies and lifetimes for low-cost, energy-efficient lighting.

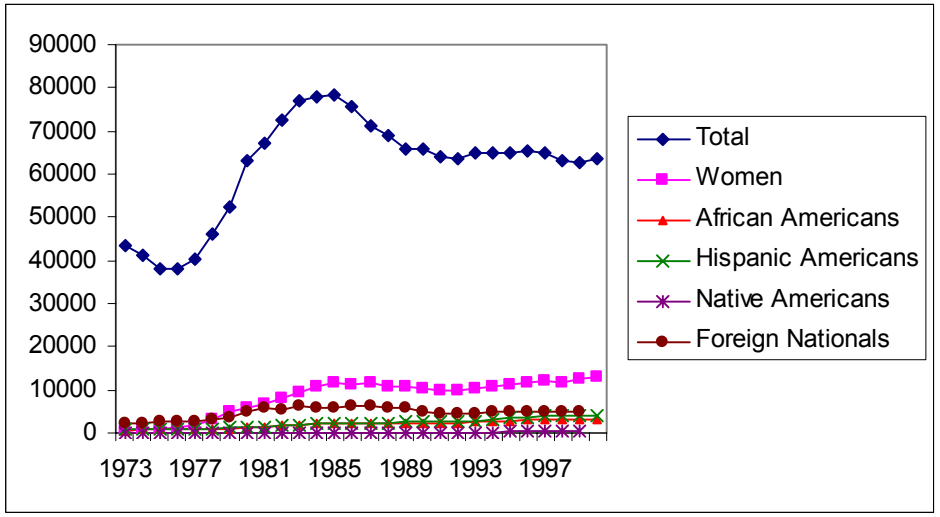
Related Engineering Workforce Issues

Engineering Degrees granted are flat or decreasing…

Engineering and Computer Science Bachelors, Masters and Doctoral Degrees 1991 - 2000

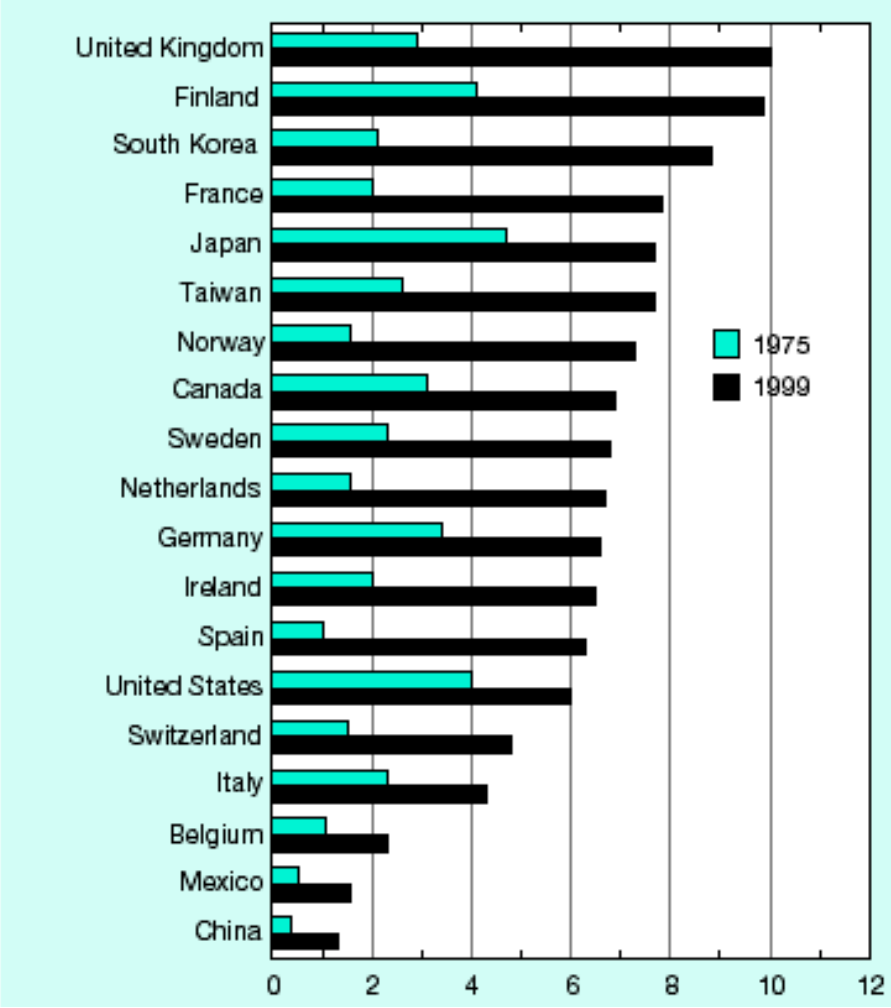


Engineering Bachelors Degrees 1973 - 2000



Source: 2002 S&E Indicators

The US lags behind other countries in the number of science and engineering graduates



Science and Engineering Graduates (Percent per capita)

Engineering Workforce for the 21st Century?

- Changing Demographics in the US
  - largest talent pool will comprise of women, Hispanics and African Americans
- Undergraduate engineering education should be restructured not only to recruit this new group but to retain them and develop them
- Engineering needs a presence in K-12 to address shrinking pipeline issue
- Supply of foreign graduate students who populate US Ph.D programs may shrink 20 years from now